sulting curves are shown in Fig. 2. When thus represented the hyperbolic character of the margin of the area of hyperpyrexia is indicated by the resulting straight line bordering the area. The curves for frequencies of 25, 60, and 90 cycles, however, do not appear as straight lines, but show distinct deviation in the region of 2 sec. The curves given in Fig. 1 are therefore the composite of 2 separate intersecting hyperbolas.

An explanation for the double curve, both components of which presumably are hyperbolic if completed, is to be found in a statement made at the beginning of the paper, namely: that the curves showing the relations of the duration of current required to produce the response of different tissues or different organs may not be coincident, but that they are approximately hyperbolic in each case. In the intact animals we are dealing in reality with the response, as death, of the vital organ which is affected by the lowest value of current. Other organs may be able to tolerate a higher value of current before they succumb to the shock, but their activities cease with failure of the organ first affected (death from any occurrence is essentially failure of only one function indispensable to the maintenance of life, rather than to any general disintegration; thus death follows heart failure, although all other organs may be capable of normal operation).

In this series of experiments the rats exposed to shocks of 2 sec or longer, if they escaped hyperpyrexia, almost invariably died of respiratory failure. Those which received shocks of less than 2 sec died of cardiac failure; this fact was emphasized by numerous spontaneous recoveries among rats exposed to presumably fatal currents but of less than 2-sec duration. In a small animal such as the rat, ventricular fibrillation (a common cause of cardiac failure in electric shock) may pass away spontaneously.

The points on the 60-cycle curve shown in Fig. 1 are plotted on log scales in Fig. 3 with the slopes of the 2 component curves extrapolated. It may be seen that for durations of more than 2 sec the curve of cardiac failure falls above that of respiratory failure. Thus when the minimum lethal current is applied, death results from respiratory failure. If, within limits, greater currents are used for the same time duration, cardiac failure may result as well; but since its effects are more rapid than those of respiratory failure, it tends to obscure the effect on the respiratory mechanism.

At time intervals less than 2 sec the conditions are reversed. The curve for respiratory failure falls at a higher current level than that for cardiac failure. Then, in cases of spontaneous recovery from ventricular fibrillation in the rat, currents greater than the minimal fatal amount may cause death by respiratory failure. The complications presented here explain some of the lack of uniformity in the results of experiments to determine the cause of death from electric shock on rats and other animals when precise attention is not given to the minimal fatal currents. The findings of the present tests afford an explanation for the common observation that death from high voltage is usually cardiac in origin, and from low voltage respiratory in origin.

Actions on Electric and Magnetic Units

The following authorized statement of the actions taken at the Paris meeting of the committee on electric and magnetic magnitudes and units of the International Electrotechnical Commission, prepared by Dr. A. E. Kennelly, chairman of the E.M.M.U. committee, is based upon the minutes of the meeting, as circulated among the various I.E.C. national committees. This statement, distributed by the I.E.C. General Secretariat in London, is, however, necessarily subsidiary to the official minutes (I.E.C. document R.M. 105) which should be consulted by those particularly interested.

By
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THE meetings (of section *B* on electric and magnetic magnitudes and units (E.M.M.U.) of advisory committee No. 1 on nomenclature, of the International Electrotechnical Commission, October 5 and 6, 1933) were held at the headquarters of the Société Française des Electriciens, 14 rue de Staël, Paris. The I.E.C. committees of 9 countries (France, Germany, Great Britain, Holland, Italy, Japan, Spain, Sweden, and the United States) were represented by delegates. The national committees of 3 other countries (Norway, Poland, and Roumania) sent in written opinions upon the subjects appearing on the agenda, which had been circulated some months in advance.

There were also in attendance Dr. A. F. Enström, president of the I.E.C., C. le Maistre, general secretary, as well as Prof. H. Abraham, general secretary of the International Union of Pure and Applied Physics, an invitation having been sent to the S.U.N. committee (symbols, units, and nomenclature) of that Union, to attend the meeting.

The minutes of the last preceding E.M.M.U. committee meeting, held in London, September 18, 1931 (I.E.C. document *R.M.* 97), were read and approved.

Name for the Practical Unit of Magnetic Flux

It was unanimously agreed to recommend to the I.E.C. national committees, the name *weber* for the

Prepared especially for Electrical Engineering. *Not published in pamphlet form.*

practical unit of magnetic flux Φ, which is equal to 10^8 *maxwells* or c.g.s. magnetic units. The name *pramaxwell* had provisionally been adopted at Oslo in 1930 for the same quantity; but objection had arisen in some national committees to the name *pramaxwell* while other national committees were content with it, or at least with the prefix *pra* as a means for effecting a transfer from a c.g.s. unit to a corresponding practical unit. The question rose as to whether, in view of the proposed adoption of the *weber*, the use of the *pramaxwell* and also of the *volt-second* should be discontinued. It was agreed to transmit this question to the national committees; but it was suggested that in order to maintain continuity in I.E.C. decisions, it might be desirable to emphasize the recommendation of the *weber*, but to leave the use of the prefix *pra* open to those who might desire for any reason to continue its use. It was also pointed out that as a matter of historical mischance, the name *weber* had been proposed by various international gatherings, in the past, for various practical magnetic units; so that it was very desirable, now that the *weber* had come before the I.E.C., that its attribution to the practical unit of magnetic flux should be definite and final.

Symbol $\mathfrak{F}$ for Magnetomotive Force (mmf)

It was agreed to recommend to section *C* on letter symbols, of I.E.C. advisory committee No. 1, that the list of electrotechnical symbols adopted at the Berlin meeting of 1913, be modified in such a manner as to make $\mathfrak{F}$ the recognized symbol for magnetomotive force and Φ the recognized symbol for magnetic flux, with no alternatives or symbols of second preference in either of these cases.

Modification of the Definition for Magnetic Flux Density B

At the I.E.C. Oslo meeting of 1930, the definition adopted for magnetic flux density *B* was:

"The magnetic flux density *B* is a vector which represents in magnitude and in direction, the state of total polarization due to a magnetic field."

Since this definition involves the attribution of polarization even to a vacuum or free space, it was considered desirable to add the following sentences, for the purpose of clarification:

The value of the flux density at a point may be determined either by the mechanical force exerted on an element of conductor carrying a current and placed at the point; or from a measurement of the electromotive force in an elementary circuit surrounding the point.

These references to the laws of Ampere and Faraday in the definition met with unanimous approval.

Magnitude of the Practical Unit of Magnetomotive Force (mmf)

The question was considered as to whether, in the practical series of magnetic units, the unit of magnetomotive force should be the *ampere-turn* or the ampere-turn/4π (*pragilbert*), the gilbert being equal to the 4πth part of the c.g.s. magnetic unit of current in one turn. The same question had been discussed at the last preceding E.M.M.U. committee meeting of London in 1931; at which meeting, marked differences of opinion had been manifested. Similar divergences of usage appear in modern electrotechnical literature. In view of the differences of opinion over the question, it was unanimously agreed to leave the matter open for further study by the national committees. It is recognized that the question is of considerable importance; because if the *ampere-turn* were definitely adopted as the practical unit of magnetomotive force, the practical series of units would logically become rationalized or at least subrationalized; whereas if the 4πth part of one ampere-turn were adopted as the magnitude of the unit, then non-rationalization of the practical magnetic series would be logically involved. It was pointed out that leaving the question undecided, each and every writer is free to use the practical units either in their rationalized or unrationalized form; but it becomes incumbent on writers to indicate clearly which form they employ.

Name for a Unit of Frequency

It was proposed by the Italian committee that the name *hertz* be given to the unit of frequency—one cycle per second. It was brought to mind that the same proposal had been considered twice before by the I.E.C.; but that the majority in favor of the *hertz* had not been held sufficient to justify its adoption. There is, however, an increasing tendency in several countries, toward the use of the *hertz* as name for the frequency unit; so that it seemed desirable to revive the question at this meeting.

The German delegation supported the Italian proposal, indicating that the *hertz* is used almost universally in German technical literature.

The American and British delegations declared themselves unable to support the proposal; not only because the *hertz* was unused in their countries, but also because the name *hertz* was not self explanatory like the phrase *cycle per second*. Moreover frequency of alternation was not discovered by Dr. Hertz and it seemed inconsistent to their national committees that the honored name of *hertz* should be applied to that physical quantity, in which various branches of science and engineering other than electrotechnics were also interested. Nevertheless, if the *hertz* could be transferred from one cycle per second to one million cycles per second, there seemed to be a possibility of overcoming these objections and of introducing it for applications in the high-frequency range, in place of the phrase *megacycles per second*.

The German delegation indicated that their committee considered it would be impracticable to change the *hertz* to one million cycles per second, in view of established usage, and that various pieces of apparatus were in service marked in *hertz* as one cycle per second. A vote being then taken on recommending the adoption of the *hertz* as the name of the unit of frequency (one cycle per second), and submitting the matter to the approval of the national committees, 7 countries voted in favor (France, Germany, Holland, Italy, Poland, Roumania, and Spain), with 3

opposed (America, Great Britain, and Japan), with 1 country abstaining (Sweden).

Name for the Practical Unit of Conductance

It was proposed by the Italian committee that the name *siemens* should be assigned to the practical unit of conductance. It was pointed out that the German committee had first made the proposition in 1911, and had followed it up on various occasions since that date.

Several delegates pointed out that although the name *mho* had never been internationally adopted for the practical unit of conductance, yet it had come into extensive use in technical literature. Other delegates expressed opposition to the *mho,* as being an unsatisfactory name; while yet other delegates considered that there was no need for a name for the practical unit of conductance. A vote was then taken on the question of whether it was desirable to assign an international name to the practical unit of conductance. Six countries voted affirmatively (France, Germany, Holland, Italy, Poland, and Roumania). Three voted negatively (America, Great Britain, and Sweden). One country abstained (Japan). It was agreed to report the result of this vote to the national committees, without making any recommendation.

Table I—Proposed Modifications

Modifications that might advantageously be introduced into certain classical magnetic formulas employing c.g.s. magnetic units, in view of the international conventions recently recommended by E.M.M.U. committee of the I.E.C. in 1930–31.

In Non-Magnetic Media, i. e., free space, a vacuum, or air assumed to be so nearly equivalent to a vacuum that its correction for magnetization may be ignored:

A. *Magnetomechanical Force f,* between 2 like poles, assumed as free point poles, each of strength m c.g.s. units, separated by a distance of r centimeters, in a nonmagnetic medium of space permeability μ_0, the *numerical* value of which is unity in the classical c.g.s. magnetic system:

Revised Formula		Classical Formula	
$f = \frac{m^2}{\mu_0 r^2}$	instead of	$f = \frac{m^2}{r^2}$	(1)

B. *Intensity of Tractive Force f′* or *Tension per Square Centimeter* exerted across an air gap or entrefer, between opposed parallel plane polar surfaces, over which the uniform magnetic flux density is B *gausses:*

$$f' = \frac{B_2}{8\pi\mu_0} \quad \text{instead of} \quad f' = \frac{B^2}{8\pi} \qquad (2)$$

C. *Magnetic Volume Energy w* in free space carrying uniform flux density B *gausses* and magnetizing force H *oersteds:*

$$w = \frac{\mu_0 H^2}{8\pi} = \frac{HB}{8\pi} = \frac{B^2}{8\pi\mu_0} \quad \text{instead of} \quad w = \frac{H^2}{8\pi} = \frac{HB}{8\pi} = \frac{B^2}{8\pi} \qquad (3)$$

In each of the above cases, the numerical results will be the same with the revised formula as with the classical formula, so long as the classical c.g.s. magnetic system is used. With other systems, however, numerical values for μ_0 differing from unity must be used, except with the Maxwell q.e.s. system (quadrant, eleventh-gram, second). In the m.k.s. system (meter, kilogram, second) unrationalized, $\mu_0 = 10^{-7}$, and rationalized $\mu_0 = 4\pi \times 10^{-7}$. In the c.g.s.s. system (centimeter, gram-seven, second) unrationalized, $\mu_0 = 10^{-9}$, and rationalized $\mu_0 = 4\pi \times 10^{-9}$. It seems, therefore, desirable to retain the symbol μ_0 in every instance as generic.

In Magnetic Media:

D. *Formula for Uniform Magnetization:*

$$B = \mu H = \mu_0 H + 4\pi \mathscr{I} \quad \text{instead of} \quad B = H + 4\pi \mathscr{I} \qquad (4)$$

where $\mathscr{I}$ is the uniform intensity of magnetization of the material.

If $\mathscr{I} = 0$, $B = \mu_0 H$ instead of $B = H$ (4a)

E. *Absolute Permeability of the Material* μ (Dividing Eq 4 by H):

$$\mu = \mu_0 + 4\pi \frac{\mathscr{I}}{H} = \mu_0 + 4\pi\kappa \quad \text{instead of} \quad \mu = 1 + 4\pi\kappa \qquad (5)$$

F. *Magnetic Susceptibility of the Material* κ (From Eq 5):

$$\kappa = \frac{\mu - \mu_0}{4\pi} \quad \text{instead of} \quad \kappa = \frac{\mu - 1}{4\pi} \qquad (6)$$

Desirability of Introducing the Symbol μ_0 Into Various Working Formulas

In view of the I.E.C. convention adopted at Oslo in 1930; namely that space permeability μ_0 is not a mere numeric, but has physical dimensions, it was unanimously agreed that in the list of working formulas appearing in Table I, it is desirable to insert the symbol μ_0 for space permeability, even when, as in the c.g.s. magnetic system, the numerical value of μ_0 is taken as unity.

Several delegates favored the recommendation to section *C*, that the symbols for absolute permeability should be changed from μ_0 to some other letter, for the reason that it was desirable to have a different symbol for absolute permeability (including permeability of a vacuum), from that for relative permeability, which is universally admitted to be a mere numeric. On putting this proposal to a vote, it was found that 7 countries favored making no change, while 2 favored a change, with 2 countries abstaining. Consequently, it was agreed to keep μ for absolute permeability, and μ/μ_0 for relative permeability, with μ_0 for the absolute permeability of vacuum or free space, as at present.

Use of the Gauss and of the Oersted

The following propositions were presented for consideration by President Janet of advisory committee No. 1, with the object of seeking an agreement with physicists:

1. In order to respect the decisions of the International Electrical Congress of 1900, and also to recognize the general usage of physicists, the *gauss* should continue to be available as the unit of magnetic field.

2. Having given that in the classical electromagnetic system, magnetic field and magnetic induction are quantities of the same dimensions, and also that both among physicists and among electrotechnicians, the usage has extended of giving the name *gauss* to the unit of induction, the use of the name *gauss* for the unit of induction is definitely authorized.

3. Electrotechnicians having found it useful and convenient, for

practical purposes, to give different names, even in the c.g.s. magnetic system to the units of magnetizing field and of induction, the name *oersted* is authorized for the name of the unit of magnetizing field.

It was recognized that the adoption of these proposals would mean annulling the Oslo conventions of 1930, and all of the international agreement concerning magnetic unitology that has been attained since that date.

Several delegates expressed the opinion that the Oslo decisions on this question should be upheld, as otherwise, if H and B were accepted as identical physical quantities, it would be illogical to assign different names to their units, and the confusion which existed prior to the Oslo convention would only be increased. While it was regrettable that no solution could be found that would satisfy all parties, yet various physicists who had been accustomed to express H in *gauss* had already adopted the *oersted* or the *gilbert per centimeter* for H and there were indications that this tendency was increasing. Moreover, much misunderstanding accompanied the use of the magnetic term field (*champ*). This term in its general sense, was susceptible of meaning either field of magnetizing force H or field of induction B. On the continent of Europe, it was generally taken as H, but in the English-speaking countries it was generally understood as B. It was therefore important to avoid using the general term *magnetic field* without specification.

Professor Janet having stated that he was personally in favor of the Oslo conventions, it was finally unanimously agreed that in view of the importance of maintaining the Oslo conventions, no action should be taken on the 3 proposals, concerning the *gauss* and *oersted*.

Inductively Reactive Power in Triangular Vector Power Diagrams

The proposition to adopt a standard method of interpreting unspecified right-angled triangle power diagrams had been considered at the E.M.M.U. committee meeting of London, but had been laid on the table until further proposals were offered by the American committee. These having been submitted, the following resolution was unanimously agreed to:

> The committee recommends that in vector power diagrams, inductively reactive power should be indicated as $-j$ *vars* plotted vertically downward, and condensively reactive power as $+j$ *vars* plotted vertically upward, it being understood that generated active power (watts) is indicated by a horizontal line drawn to the right.

This recommendation was directed to be sent to the national committees.

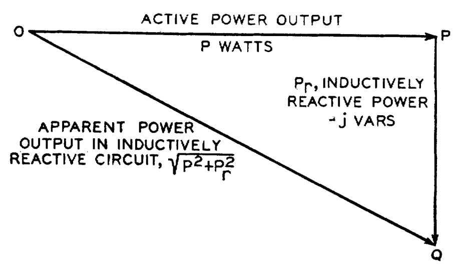

Fig. 1. Interpretation of unspecified power diagrams

Name for the Associated Practical Unit of Resistance for 1,000 Ohms

The proposition of the British committee to adopt the name *kilohm* as an abbreviation for the term *kiloohm*, representing 1,000 ohms, was unanimously approved.

Extension of the Existing Practical Units Into a Complete Practical Absolute System

Attention was called to the resolution adopted at the Chicago meeting (June 24, 1933) of the American section of the International Union of Pure and Applied Physics:

> The existing series of practical electrical units (*ohm, volt, ampere, coulomb, farad, henry, joule,* and *watt*) may advantageously be extended into a complete absolute practical system, either through the medium of the meter-kilogram-second (m.k.s.) or through the centimeter-gram-seven (10 Tonnes) and second (c.g.s.s.). Of these, the m.k.s. system is preferred for consideration.

The m.k.s. system here referred to is the system advocated by Prof. G. Giorgi since 1901.

Prof. Giorgi, who was present, gave by invitation a short explanation of the m.k.s. system and answered various questions asked by delegates. He also accepted an invitation to send to the Central Office in London a memorandum summarizing the general principles of the m.k.s. system, and of its applications to electrotechnics, for distribution to the various national committees.

Mr. Brylinski, the president of the French committee, made a short exposition of the comparative merits of the c.g.s.s. and m.k.s. systems, pointing out the superiority of the m.k.s.

Prof. Abraham drew attention to the fact that although the m.k.s. system is independent of the c.g.s. system, yet they are definitely connected, and the fundamental units of the m.k.s. system, in regard to length and mass, are identical with those whose standards are maintained by the International Bureau of Weights and Measures at Sèvres, namely, the *meter* and the *kilogram*. He advocated the importance of keeping the unit of resistance in the m.k.s. system (the *ohm*) at the definite value of 10^9 c.g.s. absolute units of resistance.

The following resolution was then unanimously adopted:

> Section *B* of advisory committee No. 1 on nomenclature, having heard with interest Mr. Giorgi's communication on the m.k.s. system, and supporting the resolution adopted by the American section of the International Physical Union at Chicago, in June 1933, decides to invite the national committees to express their views on the extension of the existing series of practical units used in electrotechnics into a complete coherent system having for its fundamental units of length, mass, and time, the meter, kilogram and second, and as fourth unit, either that of resistance defined as 10^9 c.g.s. magnetic units, of the corresponding value of the magnetic permeability of free space.

It may be observed that while the general introduction of the m.k.s. system would in no way affect the operation of the classical c.g.s. system of Maxwell in the general field of physical science, it would enable electrotechnicians to carry on their work independently through their own absolute system in which their practical units were constituent elements.